

DOCUMENT RESUME

ED 244 275

CS 208 306

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 TITLE Writing in the Biology Classroom.
 PUB DATE 8 Dec 81
 NOTE 22p.
 PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)
 -- Viewpoints (120)

EDRS PRICE MF01/PC01 Plus Postage.
 DESCRIPTORS *Biology; *Content Area Writing; Educational
 Cooperation; *Interdisciplinary Approach; Problem
 Solving; Secondary Education; Writing Evaluation;
 *Writing Exercises; *Writing Instruction; *Writing
 Skills

ABSTRACT

The writing done in a biology class has a great deal in common with the writing done in the humanities and the social sciences. Because the scientific method of investigation requires the student to examine and understand the physical world by asking questions and then answering them through empirical investigation, clear and concise writing is necessary to record the information through accurate descriptions. By using problem solving techniques, students can acquire the ability to generate new ideas through fluency, flexibility, elaboration, and a transformation of knowledge and past experiences into new forms and patterns. Peer collaboration offers the opportunity for students to criticize and correct their writing and to learn from one another. English teachers can help by grading science papers for quality, leaving the content to be graded by the biology teacher. Lab notebooks provide yet another source for writing, while writing answers to essay questions as a form of testing provides an additional evaluation of students' higher level synthesis of knowledge. (An appendix provides practical suggestions for the inclusion of writing in the biology classroom.) (HOD)

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WRITING IN THE BIOLOGY
CLASSROOM

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December 8, 1981

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Written discourse serves a variety of purposes throughout the educational process. It is a means of maintaining permanent records, a method of communication, a catalyst for creative thinking, a device for learning, and a reflection of understanding in all content areas. Unfortunately, the responsibility for writing has been traditionally placed in the hands of the English teacher, while the science teacher has been less aware of the advantages afforded by the use of writing in the science disciplines. Linguistics and rhetoric has not yet fully crossed the bridge from the English class to the science class. Although topics differ, you, the science teacher, can narrow that bridge by incorporating in your curriculum the modes of writing that are commonly used in the English classroom.

Biology teachers are in an excellent position to use writing because the content of the course is directly related to the everyday lives of the student in the form of human health, environmental issues, agriculture, botany, zoology, etc. The content of the modern biology class takes into account attitudes and skills relevant to biology that contributes to students' personal lives and to the execution of their responsibilities as men and women--and citizens of our society. Therefore, the writing done in a biology class has a great deal in common with the writing done in the humanities and the social sciences, enabling you, the science teacher, to carry writing skills into the biology classroom.

The scientific method of investigation requires the student to examine and understand the physical world by asking questions and then answering them through empirical investigation. Knowledge is derived from observation and experimentation that serves to confirm or disprove principles by which the student understands the physical universe. The typical method involves the awareness of the idea or question, then the molding of it into a working thesis or hypothesis which is tested under controlled conditions. If the experiment is successful, the results are then reported to other scientists. Clear and concise writing is necessary to record the information in a permanent fashion through accurate description of the experimental design and careful narration of the working out of the design as well as the account of the findings.¹ Science students must be capable of these skills if they are to succeed in their field. Much can be done to encourage writing in the various modes as preparation for scientific reporting.

Of course, you may retort, "But, we have special problems in science writing. Our work is very technical." I answer, "No more technical than the poetry student's analysis of the literal, symbolic, and universal meanings of a poem or the scansion and evaluation of rhetorical devices." The students in all disciplines should be taught to define all scientific terms the first time they are used. They should be encouraged to use active voice, not passive voice, to modernize the writing. Each writer must

¹Elaine Maimon and others, Writing in the Arts and Sciences (Mass: Winthrop Publishers, Inc., 1981), p. 255.

learn to anticipate the questions a reader may have and answer them as he writes, in total awareness of his audience. He must write vividly, to turn his facts into images and use examples to illustrate his ideas. These strategies are standard for all disciplines that require written discourse.

Although the focus is biology, writing and thinking are hand-holding partners. You, the teacher, should consider creativity a major part of science, for creative thinking can directly increase the students' problem solving techniques. Students need to acquire the ability to generate new ideas through fluency (producing more ideas), flexibility (searching for different types of ideas), elaboration and transformation of knowledge and past experiences into new forms and patterns.² Writing provides the means for thinking through these creative processes using the combination of the senses and the eye-hand motor controls that organize and clarify creative thinking.

Again, you may wonder, "Where will I get the time to read and correct all this written material?" I answer, "Use the best, time saving device developed by God--student power." Peer collaboration for criticizing and correcting writing enables students to learn from one another (what to avoid and what to imitate). If the peer cannot understand the writing, then no one else will. Another answer to that question is, "Use the local English teacher." Coordinate assignments so that the English

²Reuven Lazarowitz and Yehuda Huppert, "Developing Creative Thinking Skills in Secondary School Biology Students," The American Biology Teacher, Vol. 42, No. 4, (April, 1980), 226.

teacher can grade the writing quality and you can grade the scientific content. The student then gains in both areas. If that type of interdisciplinary cooperation is impossible, consider replacing long term papers with several short ones. Even three to five paragraphs can show a student's ability to organize and understand the material.

Borrow strategies from the English teacher or composition teacher and assign the reading of a particular type of report or analysis that can be used as a sample of your expectations. Perhaps have the class, as a whole, prepare a general outline for the project you have assigned. This will promote a model as well as uniformity. Collect and respond to rough drafts before you are forced to grade final papers. In this way, you can guide the student to a higher level of proficiency in organization and expression before you poise the red pencil. Life in the roll book is much easier this way.

Because much writing in the biology classroom is of a prescribed nature, lab reports present specific problems since they are prescribed by the restricted characteristics of the lab exercise.³ Similarly, scientific review papers have prescribed styles that emphasize conspicuous organization, clarity, and brevity. In these, the writer must ^{not} take a position, but must explain the state of knowledge in the limited areas.⁴ You will read more successful reports and papers if you, ²⁵⁵⁰⁷⁶ the reading of

³ Arthur P. Cooley, "Writing in Science-An Innovation," The American Biology Teacher, Vol. 42, No. 9 (Dec, 1980), p. 534.

⁴ Maimon, p. 267.

professionally written reports. The students will then have a formal model for imitation.

Lab notebooks provide another source for writing. The unambiguous recording of classroom procedures and experiment results that are written in complete sentences insures that the student understands the lab concepts. The student will also know, even before he leaves the lab, if he completely understands the purposes of the lab assignment. He should give particular attention to detail and to relationships (such as cause and effect) which will enable him to make use of the transitional language he has learned in English class: then, consequently, next, because, therefore.⁵ This relationship between the transferring of skills from composition class to biology class can once again be recognized.

Writing answers to essay questions as a form of testing in biology can also provide added bonuses to your evaluating your students' knowledge. Science teachers have been notorious for using objective tests. This format appears unrealistic because scientific results are communicated through written discourse. The use of short answer questions cannot possibly tell you what the student is thinking or if he has any understanding of the concepts you've tried so hard to impart.⁶ Short essays that require application of the facts through problem solving are superior methods of evaluating higher level synthesis of knowledge.

⁵Maimon, p. 258.

⁶Joseph J. Schwab and others, Biology Teachers' Handbook, (N.Y.: John Wiley and Sons, Inc., 1965), p.534.

As you, the biology teacher, can see, writing and learning are connected interactive processes. Writing helps the studentsto understand what they think, helps them to share their thoughts with others, and gives them the advantage of reflecting on their thoughts by reading what they have written. Writing in every discipline is a form of social behavior in that discipline. Students learn the particular conventions within the science modes and understand and appreciate the features of the written code of their area. Teaching students to write about what they learn is an important part of teaching biology.

Appendix

Practical Suggestions for the Inclusion of Writing in the Biology Classroom

Development of Scientific Vocabulary

Goal: To develop understanding of technical language
necessary for factual and conceptual knowledge

Method: In advance of an assignment or as part of the introduction to a unit, vocabulary words can be selected and studied in context. The words can then be presented in list form from which the student must develop an explanatory paragraph, expanding his information beyond the immediate word.

Group Projects That Include Writing

Goal: To provide variety through small or large group participation

Method: Special group projects can be developed that include library research, inquiries through letter writing, making records of class lectures, making records of class discussions. These lecture and discussion notes can then be drafted, edited, and "published" by the class. Along with maintaining the basic concepts of scientific facts, students add to their writing experience.⁷

⁷Cooley, p. 536.

Creative Writing in Biology

Goal: To have fun using a non-technical genre

Method: All writing need not be technical and didactic.

Students can have fun through creativity in science writing. Encourage students to write biology poems. These poems probably will not be biological or literary masterpieces, but they can be instructional, sometimes motivating, and certainly enjoyable. The poems may serve as the only successful contribution of a student whose academic achievements are few.⁸

Example:

The Heart

What a great thing I must be
Having so many arteries I look like
the roots of a tree.
I pump blood from head to toe,
No bigger than a fist as you probably
know.
I separate the used blood from the new,
I'm really one but act like two.
Blood in the veins goes one way not
the other,
I've worked hard ever since you were in
your mother.
And if you help keep me going strong,
I'll try to always beat my monotonous song.
by Cindy Godman
Woodlawn Senior High
Baltimore, Maryland⁹

Creativity can also find its way into the development of a science fiction story that applies the particular knowledge learned in class. Students find that they can have fun with their information in a new way.

⁸Albert H. Bryant, "Poetry in Biology," The American Science Teacher, Vol. 40, No. 7, (Oct., 1978), p. 440.

⁹Bryant, p. 440.

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Suggested Format for a Lab Report

Goal: To describe, document, and communicate the completion of an experiment in a natural science lab

Method: Acquaint the students with the format in advance. Request a first draft for you to check for accuracy and correctness of form in advance of the final paper.

Suggested Format:

Typical divisions

1. Title - clear and explanatory
2. Abstract - brief summary of report; tightly organized paragraph usually limited to 250 words; should answer the following questions:
 - 1) What methods are used? Mention important details about experimental subjects, the approaches, and the procedure. Write these sentences in the past tense.
 - 2) What variables are measured? Use past tense.
 - 3) What results are obtained? Use past tense.
 - 4) What conclusions can be drawn from these results? Use present tense.
3. Introduction - background and particular problem in lab exercise; main body of report begins; paraphrasing of material in text; no autobiographical material such as "I liked this lab exercise because..."
Sequence for explicit introductions: Begin by presenting background information and by

locating the lab exercise within the background information. Close the introduction with an explanation of the purpose of the experiment. Review the historical importance of the research development that led to the present state of knowledge and locate the lab exercise within these developments. Mention additional developments that go beyond the state of knowledge represented by the experiment. Reflect a professional flavor. Present the material in the following order: general information, specific information, purpose of the experiment.

4. Methods and Materials - written in complete sentences using past tense; using active voice, active has become increasingly popular although scientists have favored passive voice; using "I" and "we" for reporting; not having statements of personal feelings.
5. Results - use of figures and tables; written statements of results to highlight findings shown on figures and tables; point out trends or identify special features in data; give brief explanation of experiment; not drawing from conclusions about results.
6. Conclusion - drawn from results; summarize and cite statements in lab manual or textbook that

Revisions: May be shared with peers; may be checked by teacher while in rough draft stage; should have correctness of syntax, punctuation, spelling; should be organized into appropriate paragraphs.¹⁰

Question-Answer-Detail Method of Outlining

Goal: To organize thoughts and present facts in an orderly fashion as a preliminary activity for the development of future research, the writing of lab reports, the studying of material for an examination

Method: Teacher or students initiate questions and arrange them in the following manner to be answered.

Example: Outlining for Definition and Classification

QUESTION	ANSWER	DETAILS
1. What am I defining? (classifying)	Water	Take it for granted; see it everywhere; can be beautiful and dangerous; oceans, streams, clouds, etc.
2. What am I describing first?	Chemical composition	H ₂ O, electrolysis
3. What am I describing next?	Physical qualities	Odorless, tasteless, colorless; freezes at 30 F(ice), boils 212 F(steam); about 80% of earth's surface.
Subquestions		
1. What am I defining next?	Physical qualities.	ETC.
2. What does it look like?	Colorless,	
3. What does it taste like?	Tasteless	
4. What does it smell like?	Odorless	

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¹⁰Maimon, pp. 267-272.

¹¹Individualized Language Arts Manual, ESEA Inc. Project: 70-014, p. 72, p. 74.

Example: Outlining for Problem-Solution

QUESTION	ANSWER	DETAIL
What is the problem?		
What are the effects?		
What are the causes?		
What is the solution?		

Example: Drawing Conclusions through Thesis-Proof

QUESTION	ANSWER	DETAIL
What is the thesis or statement?		
What evidence do I have to support the thesis?		
What conclusions can I draw from the supports?		
What recommendations can I make?		

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On the following pages is an actual Question-Answer-Detail outline assigned by a biology teacher at the Hatboro-Horsham Senior High School. This activity was developed to teach students to organize their thoughts as well as to develop their awareness that television can be educational as well as entertaining. The class had been studying the phylum Arthropoda(including insects). Students viewed the video tape of the TV program entitled "The Helstrom Chronicle." They were then given the outline of questions for which

¹²ILA Manual, p. 75.

they were required to provide answers and details from the film, class discussions, and text material.¹³

¹³Kenneth Bethke, Hatboro-Horsham High Science Department.

ZOOLOGY
Mr. Bethke

NAME _____ DATE _____ PERIOD _____

DIRECTIONS: You have just viewed the video tape entitled "The Helstrom Chronicle."
This bit of material contains many startling facts which many of us are
unaware of. Organize your thoughts and the notes which you took while
viewing the tape and compile an outline using the format below:

Question	Answer	Detail
1. Who is Niels Helstrom?		
2. Why does he feel that mankind may face complica- tion before nuclear warfare may reduce our numbers?		
3. How long have insects been on this planet?		
4. Why does Helstrom feel that the final battle will be between man and insects?		
5. It was stated that man can change the environment and insects can adapt to these changes. What evi- dence is there of this?		

Question	Answer	Detail
6. In what ways has nature taken measures to reduce the insect numbers?		
7. How has the insect managed to fight back with nature?		
8. What is the instinctive drive of all insects?		
9. What is the ultimate end to all insect battles?		
10. How can some insects be compared to man?		
11. From Biblical times man has fought back, but why are we losing the battle?		

Question	Answer	Detail
12. Helstrom states that life must take life in the interest of life. Explain this.		
13. Helstrom states that man must be taught all while the insect comes on to the earth with the knowledge of a life time built in. What is meant by this?		
14. Can man ever expect to win the final battle?		

Essay Testing

Goal: to test knowledge and understanding through the use of the essay question.

Method: Students in a Hatboro-Horsham science class were required to read portions of The Bible and The Epic of Gilgamesh. Test questions then resulted in essays that evaluated the awareness of similarities within the two major literary works that describe the origin of life. Students were then required to deal with another theory, The Theory of Premordial Globes. Through the focus on who, what, where, when, why, and how, students were able to synthesize their knowledge on a higher level intellectual plane. Students also developed more confidence in presenting the answers the teacher wanted and the teacher was able to better evaluate the students' comprehension of what they read.¹⁴

¹⁴Bethke.

Name _____ Date _____ Period _____

Use reverse side of sheet for your answers.

- 1). Directions: In our pursuit of knowledge regarding Theories of Life's Origin, we discussed The Epic of Gilgamesh (written about 3000 B.C.) and excerpts from the Bible (written about 1450 B.C.). Write a paragraph comparing and contrasting the origin of life theories in each.

Who is the originator in each?

What parallelism can be found in the two theories?

Where does each theory originate?

When & Why would Moses have adapted the earlier theories?

How might we be able to use parts of each theory to better understand where life originated?

- 2). Directions: Discuss The Theory of Primordial Gels

Who is the author of this theory?

How could life have originated according to this theory?

Where could life have originated?

What would have been the necessary ingredients?

21 Why would the Theory of Evolution have to be associated along with this theory?

① The Epic of Gilgamesh, unlike the Bible was written in the first person by Gilgamesh. Moses ~~and~~ wrote the portions of the Bible in question in the third person. Seeing as they tell a very similar story (great flood, et al) it has been theorized that the Bible is a revised edition of the Epic of Gilgamesh. * The names however, were changed to Hebrew names so people could better relate to it. ~~The Bible is a revised edition of the Epic of Gilgamesh.~~

As to the origin of life, there is evidence in both selections (particularly in the Epic of Gilgamesh when our hero was elevated to a great height in a space-ship) that we were visited by more advanced beings. That ~~may~~ could imply that they brought life here, or that life developed here and we just have company over.

② Vladimir Oparin originated the theory of Primordial Soup. He suggests that chemicals ^(ammonia, nitrogen, etc) were mixed together and struck by lightning during the days when the earth was young (The tidal pools present then would have perfect for the purpose) At any rate, the electric charge would change the chemicals into very primitive organic substances. To accept this theory, evolution must ~~also~~ be accepted to explain how primordial globs developed into fish, trees, people, etc.

* An interesting point is that the King James Bible places the ^{date} when the action took place around 3000 B.C. That is the approximate time when the Epic of Gilgamesh was written.